California Regional PM$_{10}$ and PM$_{2.5}$ Air Quality Study (CRPAQS)

Statement of Work – CRPAQS Data Analysis Task 4.3
DETECTING SOURCE ACTIVITIES AND RECONCILING AMBIENT
MEASUREMENT VARIATIONS WITH FIELD OBSERVATIONS

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Sonoma Technology, Inc.

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Introduction

During the measurement phase of the CRPAQS study, STI constructed a database of visual observations of conditions near selected monitoring sites. The available information includes manually created 2-km × 2-km maps of features surrounding the sites, logs from periodic surveys of the surrounding features (every six days), and a collection of relevant news stories. In addition, a continuous photographic record of the surrounding daylight conditions at the Angiola Tower site was collected from September 2000 through January 2001. Together, these materials are a record of short-term emissions-related events and emissions sources that were present in the immediate local areas near 25 selected CRPAQS monitoring sites.

The objective of Task 4.3 is to examine the record of emission events to detect evidence (if any) that ambient air quality observations were significantly impacted by local and/or short-term emissions rather than regional emissions or atmospheric processes. We will analyze the observational record, described in the above paragraph, and the ambient data to characterize the relationship, if any, of ambient air quality measurements to local or short-term emissions sources. We will determine the extent to which specific activities from the observational record correlate with ambient air quality patterns, which may include spatial patterns, temporal patterns, variations in particle size distributions, and variations in chemical speciations. If evidence of correlations exists, Task 4.3 may provide corroboration of measurement data and/or other data analyses (such as chemical mass balance [CMB] modeling). Further, these analyses may also help to explain discrepancies between expected ambient conditions (which are modeled from emission inventories) and real-world ambient measurements or estimated source contributions. Finally, these analyses may demonstrate the local-versus-regional nature of any observed exceedences of air quality standards.

The data and information sources that are available to support the Task 4.3 analyses are listed and described in more detail below.

- Under Task 4.1, Dr. Judy Chow (Desert Research Institute) is performing CMB analyses for about 3000 samples from satellite sites and 800 samples from anchor sites. Most of these analyses will be run with conventional CMB species, and 1% will be run with

organic species. The satellite site samples have 24-hr averaging periods, and the anchor site samples have variable sampling periods: 3, 5, and 8 hours in length, depending on the start time. For the CRPAQS study, Dr. Chow will use improved speciation profiles for soils and agricultural activities, which were recently developed as a part of the California Air Resource Board's (ARB's) Technical Support Study No. 12.

- The observational database includes information for the sites listed in **Table 1**. For all the sites, hand-generated geographic information systems (GIS) maps of potential emissions sources and land-use categories were created for a 2-km × 2-km area surrounding each site. In addition, site maintenance personnel visited each of the sites every six days (and sometimes more often). They reviewed the GIS site maps and maintained logs of their observations of surrounding conditions. The logs are a periodic record of any important changes in the conditions of the surroundings.

- Digital cameras were installed at the Angiola Tower to operate from September 2000 through January 2001. These cameras captured a 360-degree view of the surroundings every two to three minutes during daylight hours.

Table 1. Sites that are represented in the observational record.

Code	Site Name	Code	Site Name
ANG*	Angiola Tower*	LVR	Livermore - 793 Rincon at Pine
BAK	Bakersfield-5558 California Street	MRM	Merced – Midtown
BTI	Bethel Island	M14	Modesto 14th Street
COP	Corcoran-Patterson Avenue	FRES	Residential area near FSF with woodburning
CLD	Crows Landing-Davis Rd	SDP	Sacramento - Del Paso Manor
DUB	Dublin	SJ4	San Jose - 4th Street
FED	Feedlot or Dairy	SEL	Selma Airport
FEL	Foothills above Fellows	SNF	Sierra Nevada Foothills
FREM	Fresno - motor vehicle	SOH	Stockton - Hazelton Street
FSF	Fresno - 3425 First Street	SWC	SW Chowchilla
HAN	Hanford - Irwin St.	VCS	Visalia - North Church Street
HEL	Helm - Central Fresno Co.	WAG	Walnut Grove
KCW	Kettleman City		

*Angiola has a continuous observational record.

Scope of Work

The analyses planned for Task 4.3 are as follows.

Analysis 1: On an ad hoc basis, coordinate with and provide information to the CRPAQS data analysis teams and to Dr. Judy Chow during her CMB analyses of PM source contributions. As needed for specific sampling periods and times, STI will review the observational record and provide feedback to Dr. Chow about observed local and short-term emissions sources and their potential effects on air quality measurements. Dr. Chow will define specific sampling periods and sites for STI to review from the observational record, which will correspond with any unusual CMB modeling results that may arise during the course of her analysis.

Analysis 2: For the Angiola Tower site, we will compare selected air quality data sets that have sampling or averaging periods of 1 hour or less with the Angiola Tower site's continuous record of photo images, which exists for the period from September 2000 through February 2001. Because the Angiola Tower site has the most finely time-resolved data sets (both for air quality and observational data), it offers the best opportunity to identify positive correlations.

We will examine the record of photo images for the Angiola Tower site and will log time periods from September 2000 through February 2001 according to whether local emission sources were observably present or not present. We will establish five types of time periods:

    (a)   daytime periods when <u>no</u> local emissions sources are observably present,
    (b)   nighttime periods when images are unavailable due to darkness,
    (c)   daytime periods when images are unavailable due to equipment maintenance or temporary malfunction,
    (d)   daytime periods when <u>one or more</u> local emissions sources <u>are</u> observably present in the upwind direction, and
    (e)   daytime periods when <u>one or more</u> local emissions sources <u>are</u> observably present in downwind or crosswind directions.

For each time period when a local emissions source is observed, a brief description of the emissions source will be created.

We will analyze the Angiola Tower's air quality data sets that are listed in **Table 2**. We will identify data outliers as data points that are outside the 1st through 99th percentile range, the 5th through 95th percentile range, and the 10th through 90th percentile range. In addition, we will calculate data distributions (e.g., averages, medians, percentiles, standard deviations) for the time periods (a) through (e) defined above. We will exclude species that tend to be products of chemical reactions in the atmosphere, such as NO_y, PAN, and HNO_3, because it is unlikely that they will be related to local emissions sources.

To complete the analysis, we will determine, on the basis of binomial probability testing, whether the rates of outliers occurring in time periods (a) through (e) vary significantly from time period to time period. In addition, we will compare data distributions for time periods (a) through (e) to ascertain whether the distributions appear to differ significantly from time period to time period. We anticipate the possibility that we will find no significant differences from time period to time period. In such a case, we will interpret the findings as evidence that the Angiola Tower site tends to be influenced almost exclusively by regional-scale emissions— as it was intended to be—and that even if short-term emissions events impact other monitoring sites, we would be very unlikely to observe the effects because the observational records are non-continuous. In this case, we will assist the ARB with plans to reallocate leftover funds from the Task 4.3 budget. However, if significant differences are observed, we will develop a plan in consultation with the ARB, Dr. Chow, and/or other researchers to conduct further potentially useful analyses for other ambient data sets, other sites, and/or other types of observational records.

Table 2.   Angiola's continuous and short-period air quality data sets selected for initial analysis.

Air Quality Measurement	Reason for Inclusion in the Analysis
Ozone (O_3)	Unusually low values could be associated with titration due to the presence of a local source of nitrous oxide (NO) emissions.
NO 2.5-μm particulate matter ($PM_{2.5}$) by beta attenuation monitoring (BAM) Black carbon (BC) by aethalometer measurement Elemental carbon (EC) by continuous OC/EC measurement Light scattering by nephelometer measurement	Unusually high values could correlate with the presence of local sources of combustion emissions, such as diesel farm equipment or on-road vehicles.
10-μm particulate matter (PM_{10}) by beta attenuation monitoring (BAM)	Unusually high values could be associated with local sources of fugitive dust or combustion emissions.
Organic carbon (OC) by continuous OC/EC measurement	Unusually high values could correlate with burning events, such as agricultural waste burning.

At the conclusion of Analysis 2, we will prepare a status memorandum to discuss findings and recommendations (if any) for further analyses and reporting. Two examples of further analyses that may be recommended at this stage are described below. However, we also will consider other possibilities that are appropriate in light of the findings of Analysis 2.

Analysis 3 (Conditional): Analyze patterns in the air quality data sets for anchor and satellite sites to determine whether high ambient concentrations correlate with short-term emissions activities. This is similar to the analysis described above for the Angiola site but differs somewhat because of the reduced frequency in the observational record. Most of the anchor and satellite sites have a discontinuous observational record with a frequency of only once in several days. However, there are some circumstances under which observations were logged more frequently. For example, continuously stationed technicians at the Sierra Nevada Foothills and Bakersfield sites recorded their observations of nearby emissions activities almost daily. In addition, emissions activities occasionally were noted to be in progress when site operators were present, which allows us to better define the corresponding sampling time period from the nearby sampling site. We will compare (1) periods when short-term activities (such as agricultural tilling) <u>were</u> observed in the upwind direction to (2) periods when <u>positively no</u> unusual activities were observed in the upwind direction, and to (3) periods when local emissions activities were <u>unknown</u> because no site operator was present.

Analysis 4 (Conditional): Compare spatial and temporal patterns in the CMB modeling results with the observational record. We will begin Analysis 4 by examining data for the Angiola Tower site. As positive correlations are identified, we will expand this analysis to other anchor sites (for which 5-hr CMB results will be available) and then to satellite sites (for which 24-hr CMB results will be available). We will compare CMB results that correspond to sampling periods when upwind activities <u>were</u> present to those that correspond to sampling periods when <u>positively no</u> activities were present (or when activities were <u>unknown</u>). Through this comparison, we will determine whether the source signatures that are indicated by the CMB analyses appear to reflect the impacts of short-term, local emissions sources.

Timeline

Figure 1 illustrates the anticipated timeline for the Task 4.3 analyses. We anticipate completing work by the end of August 2003. Our initial findings will be available by early May 2003.
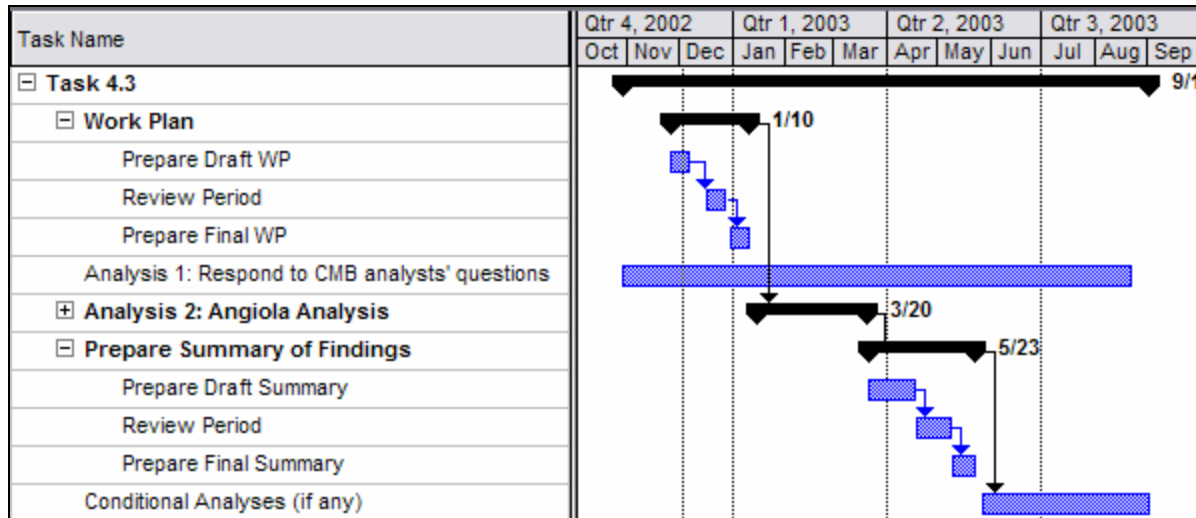

Figure 1.   Timeline for Task 4.3.

Schedule of Deliverables

Table 3 lists the deliverables to be prepared under Task 4.3 and their planned due dates.

Table 3.   Schedule of deliverables.

Deliverable	Deliverable Due Date
Draft Work Plan	December 5, 2002
Final Work Plan	January 10, 2002
Draft Summary Memorandum	April 18, 2003
Final Summary Memorandum	May 23, 2003
Presentation	Fall 2003

Description of Deliverable(s)

Draft and Final Work Plans: The work plan is intended to provide a detailed description of the work to be performed for Task 4.3. This document is the draft version of the work plan. In consideration of the reviewers' comments and suggestions, we will revise the draft version and prepare a final version.

Draft and Final versions of the Summary Memorandum: The Summary Memorandum will summarize the findings and results of Analyses 1 and 2. It will provide recommendations

(if any) for further analyses and a schedule of additional deliverables. Recommendations for further work will depend on the results of Analyses 1 and 2. In consideration of the reviewers' comments and suggestions, we will revise the draft version and prepare a final version.

Presentation: As requested, we will prepare a paper and presentation (or a poster) for the American Association for Aerosol Research meeting to be held in fall 2003.

ARB Staff Assigned to this Task

The ARB Project Manager assigned to this Task is:

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STI Staff Assigned to this Task

The STI Project Manager is Lyle R. Chinkin. The STI Task Manager assigned to this task is Ms. Dana Coe.

Percentage of Work, Data Products to be Performed/Delivered by ARB

ARB will not be required to perform any work for Task 4.3.

Software and Models to be used by STI

We will use the COARSE on-line system, Microsoft Excel spreadsheets, Microsoft Access databases, and Systat statistical analysis software to perform the described analyses. All of these products are currently installed at STI.

Models, Reports, or Other Data to be supplied to STI by ARB

To conduct the Task 4.3 analyses, we will require the following elements:

- Continuous air quality measurements for the Angiola site, listed in Table 2.

- Surface winds measured at the Angiola site, including wind direction, wind speed, and variability. Time periods for which these data are needed will be determined during Analysis 2. Hourly wind roses, or data sufficient to support creation of hourly wind roses, will be adequate.

- Further data needs will be determined in consultation with the ARB at the conclusion of Analysis 2.